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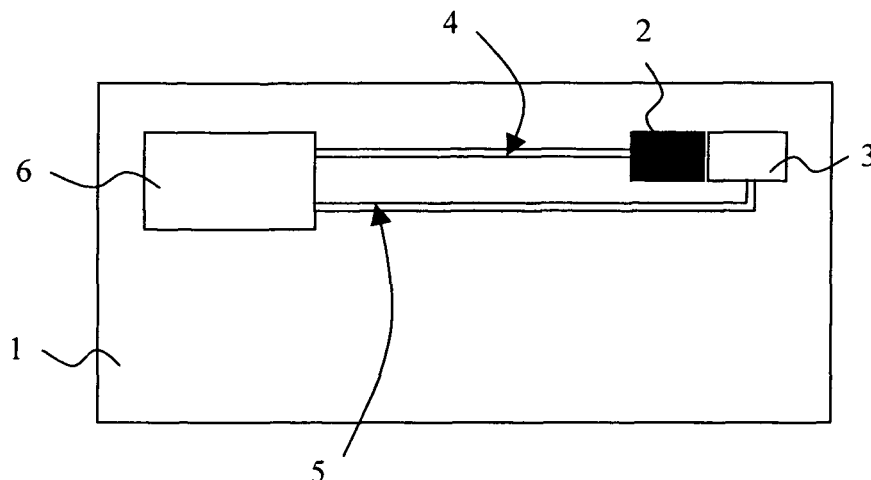
(54) **Electronic security means for security documents using an electrochemical cell**

(57) Security document comprising substrate means (1) and at least one electronic security means (6), wherein the security document also comprises at least two contact points each electrically connected to said electronic security means (6), but electrically isolated from each other.

The security document can be manufactured by provid-

ing said contact points and said electronic security means (6) on said substrate means (1). It is particularly useful for checking its authenticity, wherein said contact points are electrically connected to each other by connecting the surfaces of said contact points via an electrically conductive material and a status change of said electronic security means is observed.

FIG. 1



Description

BACKGROUND OF THE INVENTION

1. Field of the invention

[0001] The present invention relates to electronic security means for security documents such as banknotes, passports, chequebooks, etc, and more preferably to electronic security means comprising display means (such as liquid crystals, or microencapsulated electronic ink) to provide a visible display change when human skin contacts the secure document.

2. Description of the Related Art

[0002] The use of self-authenticating security features for producing documents serves for protecting them against unauthorized reproduction by forgers. This is necessary, in particular, for securities such as banknotes, checks, traveller's checks, stocks, etc. There is also a need for securing papers which do not have a direct monetary value, such as identification papers, passports etc., against unauthorized copying.

[0003] In particular, in the case of securities, which are circulated daily, for example, banknotes, a forger may succeed in copying the optically recorded document contents, for example, the optical printed image of the banknotes, in a deceptively precise way. A protection against this is the authenticity feature contained in the safety paper, used for producing the documents, as a result of the structure imparted to the safety paper during manufacture which authenticity feature supposedly practically cannot be copied by a forger with the means available to him. Moreover, the application of watermarks or the introduction of a safety thread into the paper is known. These conventional measures, however, can no longer be considered satisfactory in view of the advances of the working means employed by forgers. In particular, in the case of global political crisis regions the war-conducting groups or even entire countries employ forgery as warfare. Accordingly, the resources employed for forgery are correspondingly great.

[0004] EP 1 431 062 suggests security documents comprising substrate means, on board-electrical power supply means, such as photovoltaic cells, and electronic security means using said on-board power supply means. However the security feature cannot be activated by the user of the feature, if necessary. In addition a security feature of that kind is limited by the capacity of the power supply means and/or the availability of the corresponding power generating source.

[0005] CN 1 184 303 describes an anti-counterfeiting feature that consists of power source, controller and driver circuit and panel display. The display is produced by means of semiconductor technology and fine processing and is said to be difficult to counterfeit. However the use of semiconductor technology and the necessity for a dis-

play controller and driver circuit will limit the size, flexibility and durability of this device.

[0006] US 6 369 793 discloses a display system for magazines, advertising, toys, greeting cards, CD jackets, etc. Said display system includes a printed display formed on a substrate that is electrically connected to a printed battery, which is formed on the same substrate. The display may be electrochromic, thermochromic, electroluminescent or electrophoretic. The printed battery is a conventional wet electrochemical cell with an electrolyte-impermeable separation layer between the anode layer and cathode layer. Once the separation layer is removed the battery is activated, allowing for operation of the display. Conventional touch pad switches may be introduced to allow the display to be switched on or off after the cell has been activated.

[0007] The display system of US 6 369 793 suffers from the use of a conventional electrochemical cell, which requires an encapsulated wet electrolyte, leading to limitations in how thin the device could be manufactured and limitations in the flexibility and durability of the device. The overall thickness of this device is between approximately 125 microns and approximately 250 microns, resulting in a device that is much thicker than what is acceptable for many secure documents, especially banknotes.

[0008] Another drawback of a display system of this kind is its high rigidity and stiffness. Repeatedly bending and folding of such a display system such as during the daily use of a banknote would lead to a delamination of the multilayered anode / wet electrolyte / cathode structure and/or to the formation of cracks within one or more of said layers, which in turn would result in a leakage of the electrochemical cell and a breakdown of the cell.

[0009] In addition it has to be considered that conventional touch pad switches comprise one or more mechanically moving parts, which make or break the connections in the circuit upon activation. However the use of mechanically movable parts is not feasible within security documents that are repeatedly bent and folded during daily use.

[0010] US 4,623,598 relates to a flat battery wherein a flat generating element is sealed and sheathed with a sheathing film and both positive and negative terminals are installed on one surface of either the upper or the lower portion thereof. The positive and negative collectors are separated one from another, but electrically connected to each other via an electrolyte, such as an electrolytic solution. The battery is comparatively thin and has a high capacity per unit area. However, US 4,623,598 does not mention any possible fields of application.

SUMMARY OF THE INVENTION

[0011] The main objective of the present invention is to provide a more flexible and reliable overt security feature for secured documents that can be authenticated by a member of the general public, and which has improved

forgery-proof properties. In addition the security feature shall be highly flexible, comparable small in thickness and highly durable.

[0012] In carrying out these and other objects of the present invention, there is provided a security document comprising substrate means and at least one electronic security means, wherein said security document also comprises at least two contact points each electrically connected to said electronic security means, but electrically isolated from each other. Thereby a highly flexible and reliable overt security feature for secured documents is made available that can be authenticated by a member of the general public in a very simple way, and which has improved forgery-proof properties.

[0013] In particular, the security feature of the document can be activated by the user making an electrical contact, such as a skin contact across the surfaces of at least two contact points. This results in the generation and/or flow of small amounts of electrical power that operate the electronic security means and display the security feature.

[0014] In addition the present invention overcomes the size, flexibility and durability limitations of conventional electro-optic displays, electrical power sources and electrical interconnects. The security document of the present invention is extremely thin, since the thickness of the power source and/or switch is only dictated by the size of the contact points. In addition the security document of the present invention exhibits a very high flexibility, and a very high durability, particularly in comparison with display systems comprising conventional electrochemical cells containing an anode, a cathode and a wet electrolyte and/or conventional touch pad switches having mechanically movable parts.

[0015] Especially suitable variations of the security document of the present invention are described in the dependent products claims.

[0016] The process claims describes particularly suitable methods for the manufacture of the security document of the present invention and the use claims refer to particularly favourable ways of using the security document of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017]

FIG. 1 is a plan view illustrating a preferred embodiment of the security document of the present invention.

FIG. 2 is a perspective view (with the thickness of the components greatly enhanced) of a preferred embodiment of the security document of the present invention.

FIG. 3 is a plan view of a preferred embodiment of the security document of the present invention acti-

vated by the moisture of human skin preferably acting as an electrolyte.

FIG. 4 is a plan view of a preferred embodiment of the security document of the present invention showing an interdigitated array of the anode and cathode elements.

FIG. 5 is a plan view of a preferred embodiment of the security document of the present invention in which four set of contact points, preferably four electrochemical cells are activated simultaneously using fingertip contact from a single hand.

FIG. 6 is a cross-sectional view of an electrophoretic ink display as used in a preferred embodiment of the present invention.

FIG. 7a and 7b are plan views of a preferred embodiment of the present invention in two different active states, such that the electrophoretic display image is reversed in one active state in comparison to the second active state.

FIG. 8a and 8b are plan views of a preferred embodiment of the present invention in two different active states, such that the electrophoretic display image is reversed in one active state in comparison to the second active state.

DETAILED DESCRIPTION OF THE INVENTION

[0018] The following is a detailed description of the present invention. It provides a security document comprising substrate means and at least one electronic security means. The term "security document", as used herein refers to all kind of documents that contain at least one feature that can be used to prevent counterfeiting by providing authentication, identification or classification of the document. In particular, they include banknotes, passports, chequebooks, identity cards, credit cards and/or debit cards.

[0019] According to the present invention the security document also comprises at least two contact points each electrically connected to said electronic security means, but electrically isolated from each other. Thereby the term "electrical connection" refers to a connection via a material preferably having a resistivity ρ of less than $10^6 \Omega \cdot \text{cm}$, very preferably of less than $10^{-2} \Omega \cdot \text{cm}$, when measured at 25°C . By the way of contrast two articles will be "electrically isolated one from another" if there is no electrical connection between said articles, in particular via a material having a resistivity ρ of less than $10^6 \Omega \cdot \text{cm}$, when measured at 25°C .

[0020] The security document of the present invention is preferably adapted for checking its authenticity by electrically connecting the contact points and observing a status change of said electronic security means. Accordingly

the surface of the contact points is preferably exposed for electrical contact so that said contact points can be electrically connected to each other by connecting the surfaces of said contact points via an electrically conductive material, preferably via a material having a resistivity ρ of less than $10^6 \Omega \cdot \text{cm}$, very preferably of less than $10^{-2} \Omega \cdot \text{cm}$, when measured at 25°C .

[0021] Furthermore at least two contact points are preferably located next to each other with a separation of 0.01 cm to 1.00 cm between said contact points to allow an electrical connection via a fingertip.

[0022] The positions of the contact points on the security document can principally be chosen freely. It is merely important that the contact points are electrically isolated from each other and that an electrical connection can be achieved by connecting the contact points via an electrically conductive material. However it is of particular advantage that at least two contact points are provided on the same side of said security document in order to facilitate the application of the electrically conductive material and in particular to allow the formation of an electrical connection via one single finger.

[0023] In another especially preferred embodiment of the present invention at least one contact point is located on the front of the security document and at least one contact point is located on the back of the security document, preferably in close proximity one to another to allow the formation of an electrical connection via a electrically conductive clamp, such as the thumb and the index finger of a human hand.

[0024] According to a further preferred embodiment of the invention a plurality of sets each comprising at least two contact points are located on the substrate wherein the sets are electrically connected in a series configuration or electrically connected in a parallel configuration, or a combination of both series and parallel configurations. A member of the general public may then use the fingertips of one or more hands to simultaneously activate a plurality of sets. A series configuration of cells will provide a higher voltage whereas a parallel configuration of cells will allow the cells to operate a display with a higher current demand.

[0025] Therefore in one especially preferred embodiment the security document comprises at least two sets comprising at least two contact points and at least one electronic security means, wherein in each set said contact points are each electrically connected to said electronic security means, but wherein in each set said contact points are electrically isolated from each other (parallel configuration). Thereby at least one set preferably comprises at least anode and at least one cathode having a different electrochemical potential.

[0026] In another especially preferred embodiment comprises at least four contact points, wherein the first contact point and the fourth contact point are each electrically connected to said electronic security means, but electrically isolated from each other, and wherein the second contact point is electrically connected to the third

contact point, but electrically isolated from the first and the fourth contact point (series configuration). Thereby at least two contact points preferably have a different electrochemical potential (anode and cathode).

[0027] In principle there are no particular restrictions on the material of the contact points used in the present invention. However, the contact points preferably comprise an electrically conductive material preferably having a resistivity ρ of less than $10^6 \Omega \cdot \text{cm}$, very preferably of less than $10^{-2} \Omega \cdot \text{cm}$, when measured at 25°C .

Furthermore it is preferred that they comprise metals within the galvanic series of metals. In addition, the contact points preferably comprise at least one conductive polymer. Further information regarding the material of the contact points can be found in the technical literature, such as Falbe et al. "Römpf-Lexikon Chemie" 10. Auflage, Stuttgart, New York, Thieme 1997, keyword "Galvanische Elemente" (galvanic cells), "elektrisch leitfähige Polymere" (electrically conductive polymers) and the references cited therein.

[0028] The surfaces of the contact points are preferably left exposed to the environment. In such circumstances, it will be apparent to those skilled in the art that materials will be preferably chosen that suffer minimal tarnishing or corrosion during everyday use of the secure document.

[0029] In another preferred embodiment, a very thin layer of solid polymer electrolyte is deposited separately onto the contact points (i.e. the electrolyte does not connect both contact points) such that the materials are protected from the environment. A polymer electrolyte is preferred, as this will not detrimentally impact the desired flexibility of the invention. The ionic conductivity of the solid polymer electrolyte need only be very low, that is, equivalent or better than the ionic conductivity of human skin. Polymer electrolytes consist of salts dissolved in polymers (for example, polyethylene oxide, PEO). For good ionic conductivity these polymer electrolytes are usually prepared in an amorphous state and contain mobile ionic species such as lithium ions or silver ions. In these cases conductivities can be of the order of 10^{-3} S/m . Since these conductivities are much higher than that exhibited by human skin, these solid polymer electrolyte coatings do not impede the operation of this invention. As will be understood by those skilled in the art, various contact point materials and various suitable solid electrolyte coatings are possible, and these are considered to be covered by this invention.

[0030] In the present invention the contact points are each electrically connected to the electronic security means, preferably via one or more electrically conducting tracks. Thereby the electrically conducting tracks can be made of any electrically conducting material, but preferably have a resistivity ρ of less than $10^6 \Omega \cdot \text{cm}$, very preferably of less than $10^{-2} \Omega \cdot \text{cm}$, when measured at 25°C . The use of copper tracks has proven of particular advantage.

[0031] According to a first especially preferred embod-

iment of the present invention at least two contact points have the same electrochemical potential, preferably when measured at 25°C. Very preferably they are made of the same material. The contact points of this kind form a switch. The circuit can be made by electrically connecting said contact points via an electrically conductive material, such as human skin. On the other hand the circuit will be broken upon removal of said electrically conductive material.

[0032] The security document of this particular embodiment preferably comprises one or more power generating means, and in particular at least one battery and/or at least one photovoltaic cell. Further information regarding the power generating means can be found in the technical literature, such as Falbe et al. "Römpf-Lexikon Chemie" 10. Auflage, Stuttgart, New York, Thieme 1997, keyword "Batterien" (batteries), "Solarzellen" (solar cells) and the references cited therein.

[0033] A particular preferred arrangement of this embodiment comprises at least two sets of contact points and power generating means, wherein each set preferably comprises at least two contact points.

[0034] In a second especially preferred embodiment of the present invention at least two contact points of the security document have a different electrochemical potential, preferably when measured at 25°C. Accordingly the security document of this embodiment comprises at least one anode and at least one cathode each electrically connected to said electronic security means, but electrically isolated from each other, i. e. the electronic security means is connected to an electrochemical cell comprising at least positive pole active material (cathode) and at least one negative pole active material (anode) but missing an electrolyte electrically connecting said anode and said cathode.

[0035] Every electrochemical cell requires an electrolyte to close the electrical circuit for provision of electrical power, but it does not necessarily have to be encapsulated within the cell. The electrolyte can be provided to the cell when operation is required and fully removed after operation to once again leave dry anode and cathode materials that do not interact or degrade. For extremely low electrical current requirements, such as the present invention, this electrolyte may be in the form of the moisture (e.g. sweat) contained at the surface of human skin.

[0036] This type of cell has the advantage of having no chemical electrolyte. It is - in effect - simply two electrodes before it is touched, and in reality cannot be classed as a cell in this state. There are no problems with chemical disposal, electrolyte dry out or leakage. It can be realised in many shapes and sizes, with many different configurations. It is extremely lightweight and exhibits a very low profile, with a total material thickness of only 10 µm or less being required for operation.

[0037] In a particularly preferred arrangement of this embodiment a simple electrochemical system based on the zinc-copper galvanic couple in a saline solution is

appropriate for the intended application, with zinc as the anode material and copper as the cathode material. This is a simple galvanic system that is normally used in laboratories to demonstrate the concept of electricity; it is not widely used in commercial applications because of the low energy, power and working voltage, which it generates. However, because of the extremely low current, power and energy requirements of the electronic security means preferably used in the present invention, such as electrophoretic displays, a thin electrochemical cell based on this electrochemical couple is suitable as a power source for the electronic security means.

[0038] In a second particular preferred arrangement of the present embodiment the cathode comprises MnO₂, preferably together with carbon black to increase the conductivity of the cathode. The anode preferably comprises zinc.

[0039] In a third particular preferred arrangement of the present embodiment the cathode comprises nickel oxyhydroxide and the anode comprises zinc.

[0040] In a fourth particular preferred arrangement of the present embodiment the cathode comprises nickel oxyhydroxide and the anode comprises iron.

[0041] The actual shape of the contact points is not critical and can be square, rectangular, round or oval in shape, for example. However, the use of an interdigitated design of the contact points, preferably at least one anode and at least one cathode has proven of particular advantage.

[0042] The electronic security means of the security document is not particularly limited and can be any known in the art. However, it is particularly advantageous that the security means is an overt security feature, when activated. The term "overt feature", as used herein refers to a feature can be simply verified by a member of the general public using just the feature itself, and with no requirement for additional apparatus. Features in which the feature can only be read by special machine apparatus are so-called "covert features" which are not preferred for the purposes of the present invention.

[0043] In addition the electronic security means is preferably a low power display means having an electric power consumption of preferably 10⁻⁵ W or less. For example, if the moisture content within human skin is used as an electrolyte for an electrochemical cell, the power source will have a high internal impedance that is of the order of 10⁵ to 10⁶ Ω. The electrical current that can be drawn from the power source is consequently very low and is of the order of 10⁻⁵ to 10⁻⁶ A. The potential voltage of the power source is dependent on both the nature of the anode and cathode materials used in the electrochemical cell, and the number of cells connected electrically in series with each other. For the particular embodiment of invention that uses the copper-zinc galvanic cell, the potential voltage can range from approximately 0.3 V for a single cell to approximately 1.6 V for four cells in series activated by a single user.

[0044] Particularly suitable electronic security means

for the purposes of the present invention include electrophoretic ink display means and/or liquid crystal display means.

[0045] The kind of the substrate means used in the present invention is not critical. However the use of substrate means comprising paper, plastic, polymer, elemental metallic foils, metallic alloy foils and/or synthetic paper is preferred.

[0046] The security document of the present invention is comparatively thin and its thickness is preferably smaller than 100 μm . In one especially preferred embodiment, the overall thickness of the contact points, preferably at least one anode and at least one cathode, not including the substrate thickness, is between approximately 10 to 50 μm . The thickness of the interconnects between the power source and the display is preferably within the range from approximately 1 to 30 μm . The thickness of the electronic security means, not including the substrate means, depends on the kind of security means actually used, but is preferably in the range from 25 to 300 μm .

[0047] Methods for the production of a security document of the present invention are obvious to the skilled person. The substrate means is preferably provided with the contact points, in particular the anode and the cathode, and the electronic security means, wherein all components, including the electronic security means, may be printed onto a common substrate. Alternatively, for substrates that are not compatible with the manufacturing techniques required for the electronic security means, the power source and interconnects may be printed onto the substrate whereas the complete display assembly may be subsequently attached to the substrate. In this latter case, electrical connection will be made by ensuring that exposed printed contact pads on the substrate align with contact pads on the electronic security means.

[0048] In a specific embodiment of the present invention the conducting tracks and/or the contact points, in particular the anode and the cathode, are deposited onto the substrate using an electroless deposition technique. In this technique a specially formulated catalytic ink is printed onto the substrate in a desired pattern. The substrate is then immersed in a chemical solution containing ions of the metal to be deposited. Over time, electroless deposition of the metal onto the substrate areas printed with catalytic ink occurs. This technique is advantageous compared to other methods for producing the desired electrically conducting tracks and the contact points, such as printing of metal-loaded inks, since the technique produces deposited material with a density that is very close to that of the bulk material. Furthermore, this technique is advantageous over standard printing of loaded inks in that the adhesion of the deposited material to the substrate is superior. The - aforementioned electroless deposition technique is described in detail in Patent Application WO 02/099163 and is suitable for a range of substrates (such as polyester, polypropylene, synthetic paper, fine-weave cloths and polycarbonate) and a range of deposited metals (including copper, nickel, cobalt, iron,

tin and a variety of magnetic and non-magnetic alloys). However, the present invention does not preclude other methods of depositing electrically conducting materials and/or anodic or cathodic active materials. Other methods include printing (such as screen printing and gravure printing) of particle-loaded inks, electroplating methods, chemical vapour deposition, sputtering and etch-resist methods, all of which are known to those skilled in the art.

[0049] For checking authenticity of the security document of the present invention the contact points, preferably the anode and the cathode, are electrically connected to each other by connecting the surfaces of said contact points via an electrically conductive material preferably having a resistivity ρ of less than $10^6 \Omega \cdot \text{cm}$, very preferably of less than $10^{-2} \Omega \cdot \text{cm}$, when measured at 25°C and a status change of said electronic security means is observed. Thereby an electrolyte is preferably used. The electronic security means is activated by said addition of an electrically conductive material to the security document. In this invention the electrically conductive material is required to only have a very low level of ionic conductivity, since for electrophoretic-type displays, such as microencapsulated electrophoretic inks or electrophoretic liquid crystal-type displays, only a very low level of electrical current is required for operation of the display. In fact, it has been discovered that the transport properties of the surface of human skin is sufficient to meet the required ionic conductivity- even 'dry' skin is sufficient - for operation of electronic security means, in particular of electrophoretic displays. Accordingly the use of an electrolyte comprising water, preferably of saline solution and/or the moisture of human skin is particular favourable.

[0050] In an especially preferred embodiment of the present invention the activation is achieved by the moisture of human skin, such that when the skin contact is removed from the contact point surfaces the security document immediately reverts back into a non-activated state. Other forms of electrolyte, liquid or otherwise, such as moisture-containing sponges or electrolytic gel, may be introduced to the contact points to switch the security document from a non-active state to an active state, and subsequently removed, by for example wiping dry, to switch the security document back to a non-active state, and these are contemplated as falling within the scope of the present invention.

[0051] Referring now to the figures, several preferred embodiment of the invention each comprising a dry electrochemical cell will be discussed. FIG. 1 is a plan view of a first particular embodiment of the present invention. The cathode material 2 and the anode material 3 are preferably printed on the substrate 1 and make up the dry electrochemical cell. Electronic security means 6, preferably a display, which may be by way of example an electrophoretic liquid crystal display or a microencapsulated electrophoretic ink display, is either printed or, in a separate process, adhered to the substrate means 1. The cathode material 2 and the anode material 3 are

electrically connected via electrically conducting inter-connecting tracks 4 and 5 preferably printed on the substrate means 1 to the electronic security means 6. There is no electrolyte between the cathode 2 and the anode 3 and there is no direct electrical connection between cathode 2 and anode 3 except via the electrophoretic display 6. As such, FIG. 1 is a view of a preferred embodiment of the present invention in a non-active state.

[0052] In a specific embodiment of the present invention, shown in FIG. 2 in perspective view with the thickness of the deposited components greatly enhanced for clarity, the electrically conducting tracks 4 and 5 are preferably formed from copper and are preferably deposited using the electroless deposition technique. The electrically conducting tracks may be printed before or after the display 6 is printed onto the substrate or attached to the substrate, but in each case electrical connection is made to the electronic security means. Alternatively, and potentially leading to a more robust security document, the electrode conducting tracks are deposited during appropriate steps of the manufacture of the display, as will be explained hereafter. The cathode material 2 is preferably formed from copper and is preferably also deposited using the electroless deposition technique. This may be deposited simultaneously with deposition of the electrically conducting tracks.

[0053] The thickness of the deposited copper using this deposition technique is preferably about 5 μm , which is deemed suitable for the present invention although electroplating techniques may be used to further increase the thickness of the copper on the conducting tracks and cathode as required. In this specific embodiment a thin layer of copper 7 is preferably also deposited, using the electroless deposition technique, at the anode location and this may be deposited simultaneously with deposition of the conducting tracks and the cathode. Zinc material 3 is then deposited on top of this first copper layer at the anode location preferably by screen printing using an ink with solid loading by volume of zinc between 40% and 60%. Fine conducting powder material may be added to this ink, such as carbon black powder, to increase the conductivity of the zinc loaded ink. It is understood that any method of printing may be used to deposit such a solid loaded ink. In this particular embodiment the thickness of the conducting tracks is of the order of 5 μm , the thickness of the cathode element is about 5 μm and the thickness of the zinc material is approximately 15 μm .

[0054] In a further embodiment of the present invention the zinc anode is deposited by electroplating on top of the copper layer 7 at the anode location 3; during this electroplating process all other copper regions are preferably masked to prevent deposition of zinc elsewhere. Alternative anode materials may be deposited on top of the copper layer. In a similar manner, a different cathode material, that is, for instance, more positively active within the galvanic series than copper (such as silver), may be deposited at the cathode location, and such embellishments are considered to be covered by the present in-

vention.

[0055] Other electrically conducting materials may be used for the interconnections between the galvanic cell and the display, and other anode and cathode materials may be used, metallic or otherwise, as will be familiar to those skilled in the art of electrochemical cell design.

[0056] In a preferred embodiment of the invention the moisture contained within the human skin is used as the electrolyte. Referring to FIG. 3, biologically active human skin (i. e. human skin comprising at least some water, such as the skin of a living human being), in the form of the inner surface of a thumb or finger 8 of a member of the general public, is pressed over the surfaces of the cathode 2 and the anode 3. In this situation the invention is said to be in an active state. The moisture content of human skin acts as an electrolyte for the cell such that the cell generates an electric potential and allows a very small amount of electric current to flow. With specific design of the cell and careful choice of the display the generated potential and current is sufficient to operate the electronic security means. The moisture content and the salinity of human skin can vary greatly from person to person, even before environmental and physical conditions have been considered. For direct current (dc) conductivity and low frequencies the electrical impedance of human skin is dominated by the outermost (stratum corneum) layer of the epidermis layer of skin. The thickness of this layer can vary between 10 μm and 1 mm according to the amount of protection and/or grip required by a region of the body. For example, the hands are typically used to grasp objects, requiring the palms to be covered with a thick stratum corneum (about 200 μm thick). Similarly, the sole of the foot is prone to injury, and so it is protected with a very thick stratum corneum layer (about 1 mm thick). This stratum corneum layer can act as a solid state electrolyte with only a few free ions required for dc conductance. The cells of the stratum corneum layer can absorb water and this has a marked effect on the electrical conductivity of human skin. The electrical conductivity of human skin, at a frequency of measurement of 1 Hertz, can vary between about 10^{-7} S/m for dry skin to about 10^{-5} S/m for wet skin; and a typical resistance value as measured between two contact points is $\sim 10^5 \Omega \text{ cm}^2$.

[0057] For a particular preferred embodiment using copper as the cathode material and zinc as the anode material, the electric potential generated by the cell through the use of skin moisture as an electrolyte can be predicted from the galvanic series of metals in saline solution to be approximately 0.6 V to 0.7 V. The potential generated into a Digital Voltmeter with an internal impedance of $10^6 \Omega$ for this embodiment of the invention is about 0.5 V upon pressing a dry finger across the copper and zinc samples. The internal resistance of this activated cell is estimated to be about 0.4 Megaohms. Consequently, the cell has a high internal resistance and is only suitable for operating devices that present a much higher resistance to the cell, and that require very small electrical

current for their operation. For this reason, electrophoretic displays, which are capacitive in nature and have a very high dc resistance, are particularly suitable for direct operation from these skin-activated galvanic cells. It will be apparent to those skilled in the art that other display types may be compatible with such power sources, and these are hence contemplated as falling within the scope of the present invention. Improving electrolyte salinity and moisture content will reduce the internal resistance of the cell, thus improving its current-sourcing capability.

[0058] In a further embodiment of the invention the anode and cathode materials are deposited in an interdigitated pattern as shown in FIG. 4. The fingers of the comb array of the anode 9 fit between the fingers of the comb array of the cathode 10. Any number of fingers may be used and the separation between anode and cathode may be of any distance but is limited by the resolution of the various printing and deposition methods mentioned earlier. This arrangement has the advantage that the activated cell (that is, when pressing human skin across the interdigitated array) has a lower internal resistance and will thus be able to produce more current into a given load, when compared to the embodiment shown in FIG. 1. Many other geometrical arrangements of the anode and cathode are possible and these are considered to be covered by this invention.

[0059] For a number of electrophoretic display types (as will be discussed later), a higher potential voltage than that provided by the simple galvanic cell previously described is required to operate the display. Higher voltages may be achieved, to some extent, by changing the nature of the anode and cathode to more negatively active and more positively active materials, respectively. However, another option is to arrange the cells electrically in series, as shown in plan view in FIG. 5. In this particular embodiment of the invention four of the galvanic cells are arranged electrically in series such that the negative pole (preferably a zinc anode) of one cell is in electrical contact with the positive pole of the next cell (preferably a copper cathode).

[0060] In practice, in order for the voltage potentials from series cells to sum up, the cells should not share the same electrolyte, as is the case for this particular embodiment of the invention. However, human skin exhibits a relatively large impedance between two points (e.g. two fingers, or two hands). This, coupled with the fact that a display with extremely high impedance is connected to the cells, allows the cells to be connected in series whilst effectively sharing the same electrolyte. The impedance of the skin between fingertips separates the electrolytes with an impedance that is greater than each individual cell impedance, and therefore does not shunt the cell. In this particular embodiment, the four cells connected in series, simultaneously activated by four fingertips from one hand, provide a potential difference of 1.6V. This is higher than that provided by a single cell but, as expected, does not quite equal the sum of the potential provided by four individually operated cells.

[0061] In a particular preferred embodiment of the present invention, a printed electrophoretic display 11, shown in cross-section view in FIG. 6, may be used as the display 6 in the self-authenticating feature. The display comprises a substrate 12 which may also be the same as the substrate means 1. An electrode layer 13 is then formed on the substrate layer. This bottom electrode layer may be printed, using for example a silver ink, or deposited using the electroless deposition technique previously described and as referred to in Patent Application WO 02/099163. The bottom electrode layer may be printed simultaneously with one of the electrical tracks (4 or 5) and in this manner connection between the dry electrochemical cell and the display is facilitated. Other methods of forming the electrode layer will also be apparent to those skilled in the art, and these are contemplated as falling within the scope of this invention. An electrophoretic layer 14 is then formed on top of the electrode layer by printing for example, although other deposition methods are considered to be covered by the present invention. A suitable electrophoretic layer would be composed of, for example, electronic ink. The electronic ink can constitute micro-encapsulated charged particles within an ink carrier. Moreover, the electronic ink may be composed of any suspension of electrically charged or electrically polarisable pigment particles contained in a fluid or ink carrier, and this is contemplated as falling within the scope of the present invention. Finally, a transparent electrode layer 15 is formed over the electrophoretic layer. Preferably the transparent electrode material is indium tin oxide (ITO) although other transparent conductive materials may be used and are contemplated as falling within the scope of the present invention. The transparent electrode layer may be deposited by means of a vacuum-deposition or sputtering process, but preferably, for the present invention, ITO inks are deposited using a printing process (as per US Pat. No. 5421926). Printing of the top electrode layer 15 may be undertaken simultaneously with printing of the remaining electrical track (5 or 4) such that electrical connection to the electrochemical cell is facilitated. When a voltage with a first polarity is applied across the electrodes 13 and 15 an electric field is generated within the electrophoretic layer 14. The electric field exerts a force on the pigment particles, which move towards the transparent electrode, thus producing the colour of the pigment to the viewer 16. When a voltage with opposite polarity is applied to the electrodes 13 and 15, the pigment particles are attracted to the bottom electrode such that the colour of the ink dye is observed. It is preferable that the particles are light with high scattering coefficients (as is the case for titanium dioxide) in a dark-dyed ink medium. Since the display behaves electrically as a capacitor, only a small amount of power is required for operation of the display. Because the display is capacitive in nature, and the fact that the display change relies on the movement of particles within a fluid medium, there is a finite time taken for the display to change state that is depend-

ent upon the potential voltage applied to the display. It is found that for observation of a colour change from such a display within a reasonable time period (<20 seconds) the required applied potential voltage was about 1 volt. Lower voltages may be achieved by reducing the separation between the electrodes 13 and 15 since this will give rise to a higher electric field within the electrophoretic layer. Additional information regarding electrophoretic displays using electronic inks can be found in US Pat. No. 5604027, US Pat. No. 5872552, US Pat. No. 6323989, US Pat. No. 6480182 and US Pat. No. 6665042.

[0062] In a particular embodiment of the present invention, shown in FIG. 7a, two adjacent electrophoretic displays 17 and 18 and four dry electrochemical cells are configured such that when two of the electrochemical cells are activated (when the user presses fingertips across each of the cells simultaneously, and the remaining two electrochemical cells are in the non-active state) one display 17 is provided with a negative polarity and the other adjacent display 18 with a positive polarity. This has the effect of making one display appear black and the other appear white, thereby enhancing the contrast to the viewer. In FIG. 7a the electrical track 19 is connected to the bottom electrode 12 of the electrophoretic display that is common to both display 17 and display 18. The electrical track 20 is connected to the top electrode 15 of electrophoretic display 17 and electrical track 21 is connected to the top electrode 15 of electrophoretic display 18. Thus in FIG. 7a the bottom two electrochemical cells are activated such that the left half of the electrophoretic display is black whilst the right half of the electrophoretic display is white. The top two cells of this particular embodiment are reversed in polarity such that when these are activated (and the bottom two cells are in the non-active state), as shown in FIG. 7b, image in the display reverses such that the left half of the electrophoretic display is white whilst the right half of the electrophoretic display is black

[0063] In actual fact the connection to the bottom electrode of this electrophoretic display is not required, since the potential applied to the top electrodes of the electrophoretic displays will always be referenced against the common bottom electrode of displays 17 and 18. As such the same effect may be observed by the configurations shown in FIG. 8a and 8b: the electrical track 22 is connected to the top electrode 15 of electrophoretic display 17 and the electrical track 23 is connected to the top electrode 15 of electrophoretic display 18. A plurality of cells with different polarities could be considered, each connected to different elements within the electrophoretic display and this is considered to be covered by the present invention. Each electrochemical cell could be activated, by making skin contact across the anode and cathode elements of each cell, individually or in combinations that are designed to give rise to a particular display feature. In this way, the complexity of the feature is enhanced to provide a feature that is more difficult to counterfeit.

[0064] It will be apparent to those skilled in the art that the voltages and low currents generated by the skin-activated electrochemical cells may be used to operate other types of displays. By way of example, liquid crystal-based displays are also electrophoretic in that the application of a voltage to the display creates an electric field, which causes rotation or other movement of molecules or particles within the display. As such, liquid crystal displays require very low electrical currents and may be suitable for operation with the high impedance, skin-activated electrochemical cells described in this invention. By way of further example, only a very low level of electrical current, of the order of ten microamps, is required to illuminate a single pixel of a polymer-based light emitting diode, and these may therefore also be suitable for operation with the skin-activated electrochemical cells. The operation of other display types using these skin-activated electrochemical cells is contemplated as falling within the scope of the present invention.

[0065] In principle, the specific arrangements shown can also be used when the contact points have the same electrochemical potential, and preferably are made of the same material. In order to operate the electronic security means the security document preferably also comprises power-generating means and/or power-generating means are preferably connected to the security document when making the electrical contact between the contact points. The use of power-generating means located on the security document is particularly preferred.

Claims

1. Security document comprising substrate means and at least one electronic security means, **characterized in that** the security document also comprises at least two contact points each electrically connected to said electronic security means, but electrically isolated from each other.
2. Security document according to claim 1, **characterized in that** said security document is a banknote, a passport, a chequebook, an identity card, a credit card or a debit card.
3. Security document according to claim 1 or 2, **characterized in that** the security document is adapted for checking its authenticity by electrically connecting the contact points and observing a status change of said electronic security means.
4. Security document according to at least one of the preceding claims, **characterized in that** at least two contact points are located next to each other with a separation of 0.01 cm to 1.00 cm between said contact points.
5. Security document according to at least one of the

- preceding claims, **characterized in that** said contact points can be electrically connected to each other by connecting the surfaces of said contact points via an electrically conductive material.
6. Security document according to at least one of the preceding claims, **characterized in that** at least two contact points are located on the same side of said security document.
 7. Security document according to at least one of the claims 1 to 5, **characterized in that** at least one contact point is located on the front of the security document and at least one contact point is located on the back of the security document.
 8. Security document according to at least one of the preceding claims, **characterized in that** said security document comprises at least two sets comprising at least two contact points and at least one electronic security means, wherein in each set said contact points are each electrically connected to said electronic security means, but wherein in each set said contact points are electrically isolated from each other.
 9. Security document according to at least one of the preceding claims, **characterized in that** said security document comprises at least four contact points, wherein the first contact point and the fourth contact point are each electrically connected to said electronic security means, but electrically isolated from each other, and wherein the second contact point is electrically connected to the third contact point, but electrically isolated from the first and the fourth contact point.
 10. Security document according to at least one of the preceding claims, **characterized in that** the contact points comprise an electrically conductive material.
 11. Security document according to claim 11, **characterized in that** said contact points comprise metals within the galvanic series of metals.
 12. Security document according to claim 10 or 11, **characterized in that** said contact points comprise at least one electrically conductive polymer.
 13. Security document according to at least one of the preceding claims, **characterized in that** at least one contact point comprises an electrolyte coating.
 14. Security document according to at least one of the preceding claims, **characterized in that** contact points exhibit resistance to oxidation and/or tarnishing from exposure to the atmospheric environment.
 15. Security document according to at least one of the preceding claims, **characterized in that** said security document comprises electrically conducting tracks connecting said anode and said cathode to said electronic security means.
 16. Security document according to at least one of the claim 10 to 15, **characterized in that** at least two contact points have the same electrochemical potential.
 17. Security document according to claim 16, **characterized in that** the security document comprises power-generating means.
 18. Security document according to claim 17, **characterized in that** said security document comprises a battery or a photovoltaic cell.
 19. Security document according to claim 16 or 17, wherein the security document comprises at least two sets of contact points and power-generating means.
 20. Security document according to at least one of the claim 10 to 15, **characterized in that** at least two contact points have a different electrochemical potential.
 21. Security document according to at least one of the preceding claims, **characterized in that** said electronic security means is an overt security feature.
 22. Security document according to at least one of the preceding claims, **characterized in that** said electronic security means is a low power display means.
 23. Security document according to claim 13, **characterized in that** said low power display means are electrophoretic ink display means and/or liquid crystal display means.
 24. Security document according to at least one of the preceding claims, **characterized in that** said substrate means comprises paper, plastic, polymer, elemental metallic foils, metallic alloy foils and/or synthetic paper.
 25. Security document according to at least one of the preceding claims, **characterized in that** its thickness is smaller than 100 μm .
 26. Method for the production of a security document according to at least one of the preceding claims, wherein said contact points and said electronic security means are provided on said substrate means.
 27. Method according to claim 26, **characterized in that**

said contact points are printed onto said substrate means.

28. Method according to claim 26 or 27, **characterized in that** said contact points are deposited onto said substrate means by using electroless deposition, sputtering and/or vacuum deposition. 5
29. Method according to at least one of the claims 26 to 28, **characterized in that** electrically conducting tracks are deposited onto said substrate means by the use of electroless deposition, sputtering and/or vacuum deposition. 10
30. Method according to at least one of the claims 26 to 29, **characterized in that** electrically conducting tracks are printed onto said substrate means by the use of conductive inks. 15
31. Method according to at least one of the claims 26 to 30, **characterized in that** said contact points and electrically conducting tracks are provided simultaneously. 20
32. Method according to at least one of the claims 26 to 31, **characterized in that** said electronic security means is provided before or after the provision of said contact points. 25
33. Method according to at least one of the claims 17 to 23, **characterized in that** said electronic security means and/or said contact points are provided on both sides of said security document. 30
34. Use of a security document according to at least one of the claims 1 to 25 for checking its authenticity, wherein said contact points are electrically connected to each other by connecting the surfaces of said contact points via an electrically conductive material and a status change of said electronic security means is observed. 35
40
35. Use according to claim 34, **characterized in that** an electrolyte is used as said electrically conductive material. 45
36. Use according to claim 35, **characterized in that** said electrolyte comprises water.
37. Use according to claim 36, **characterized in that** said electrolyte comprises moisture of human skin. 50

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FIG. 1

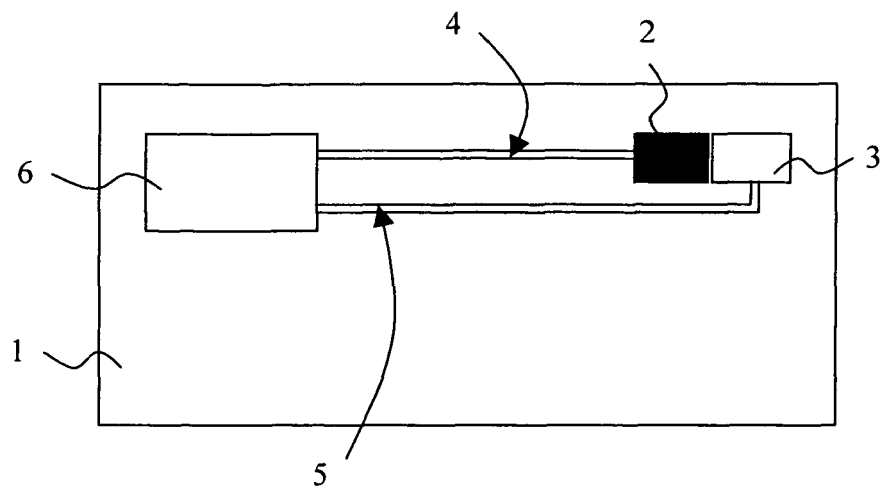


FIG. 2

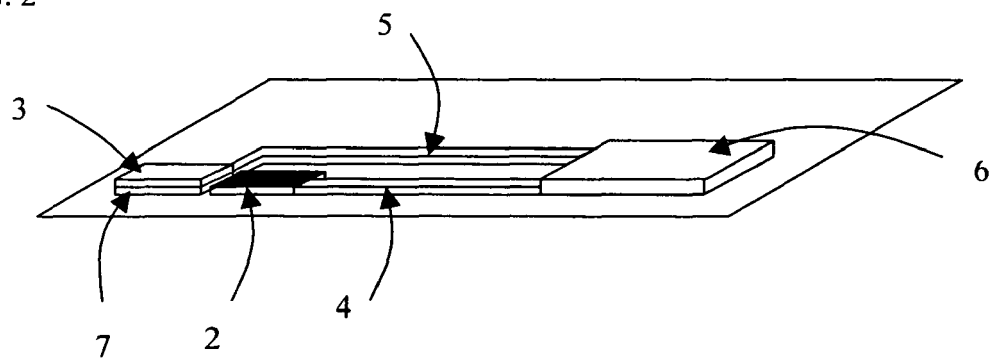


FIG. 3

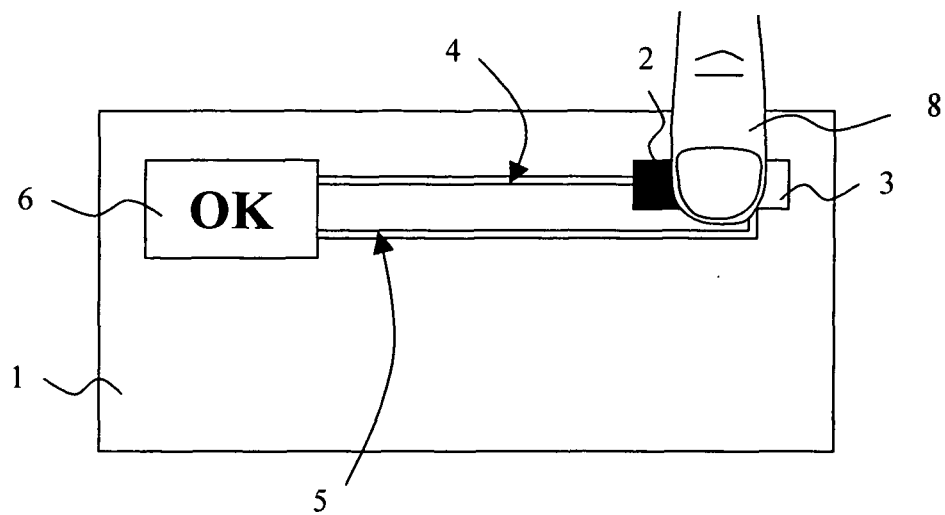


FIG. 4

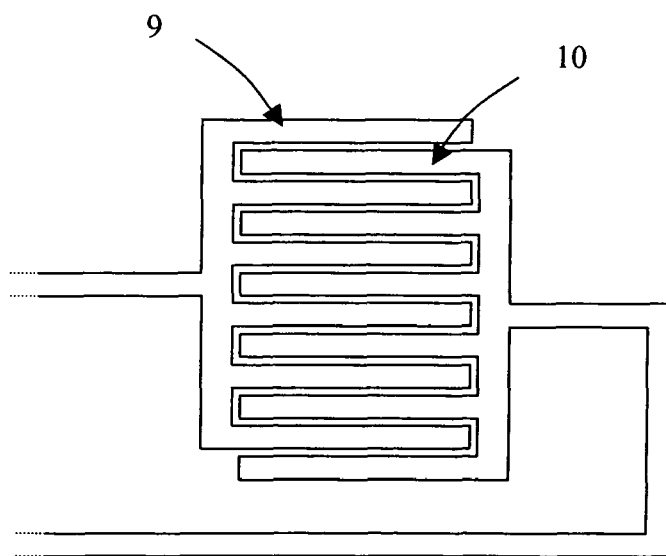


FIG. 5

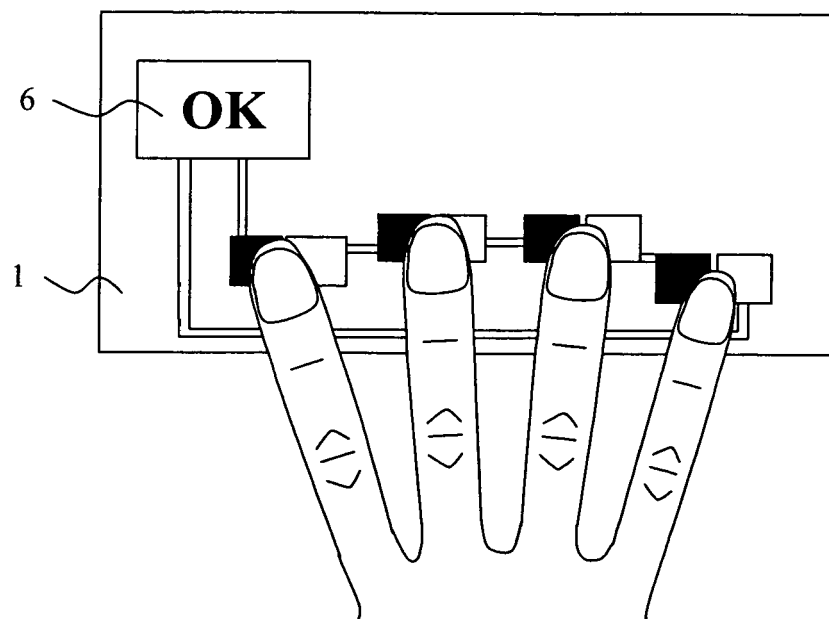


FIG. 6

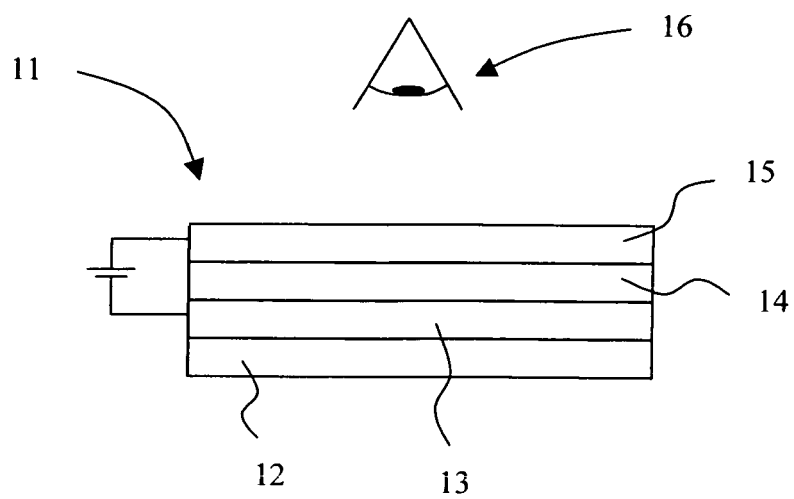


FIG. 7a

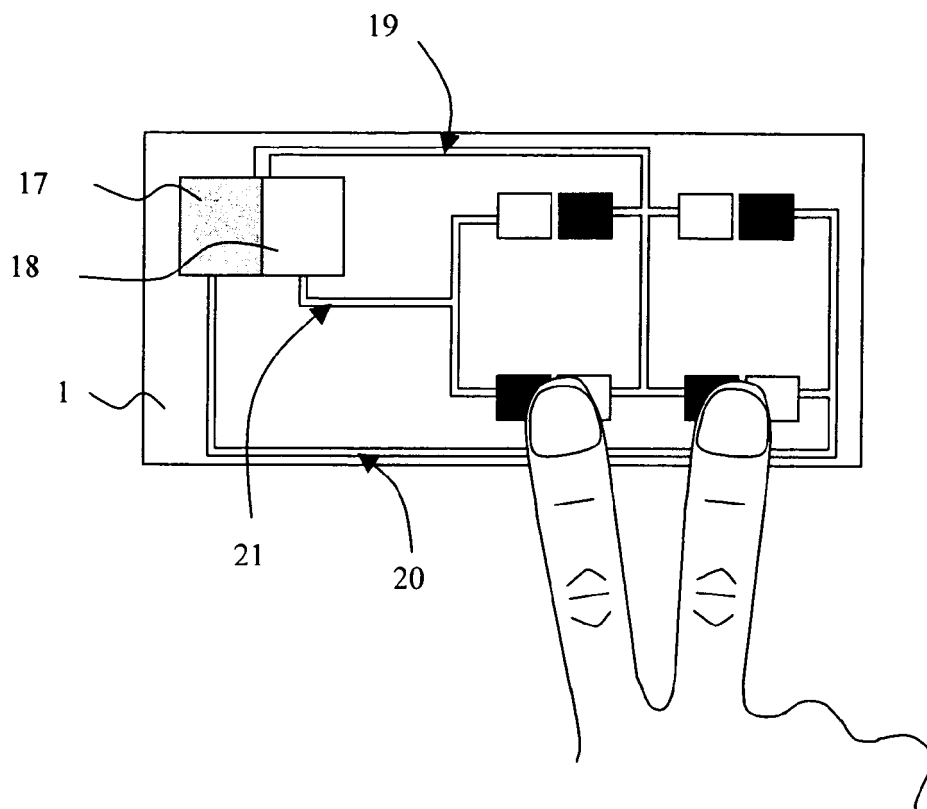


FIG. 7b

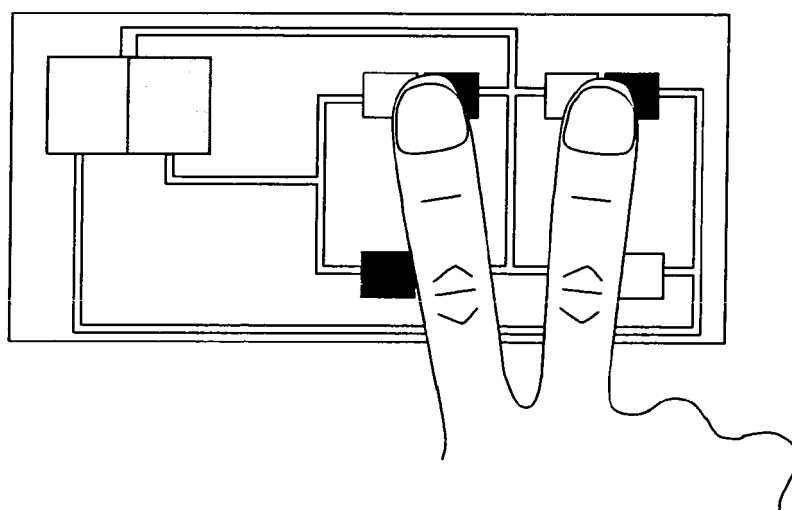


FIG. 8a

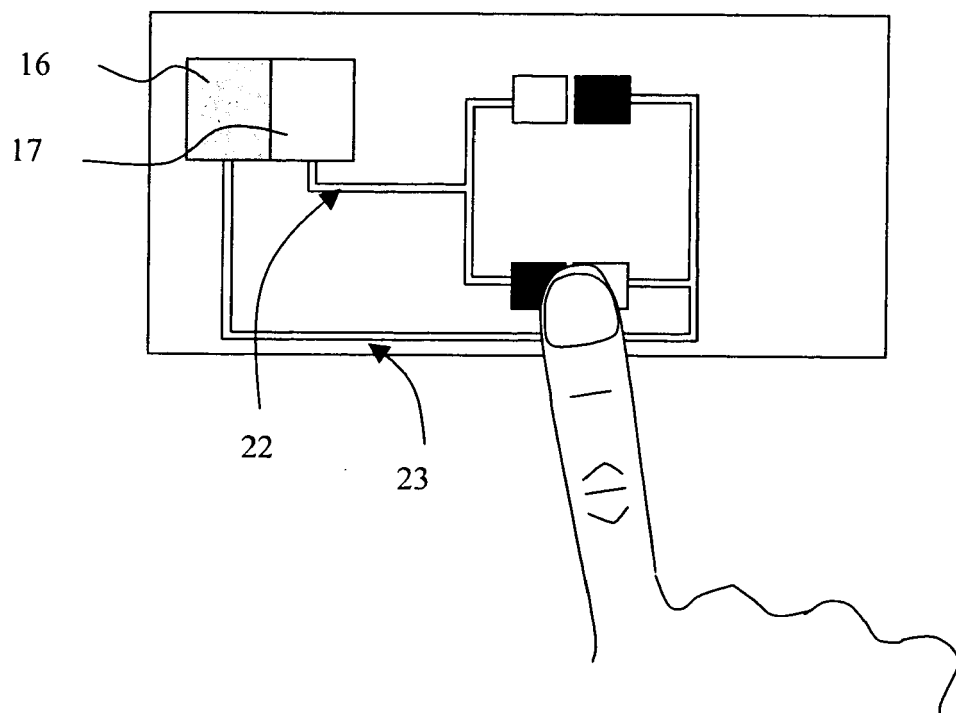
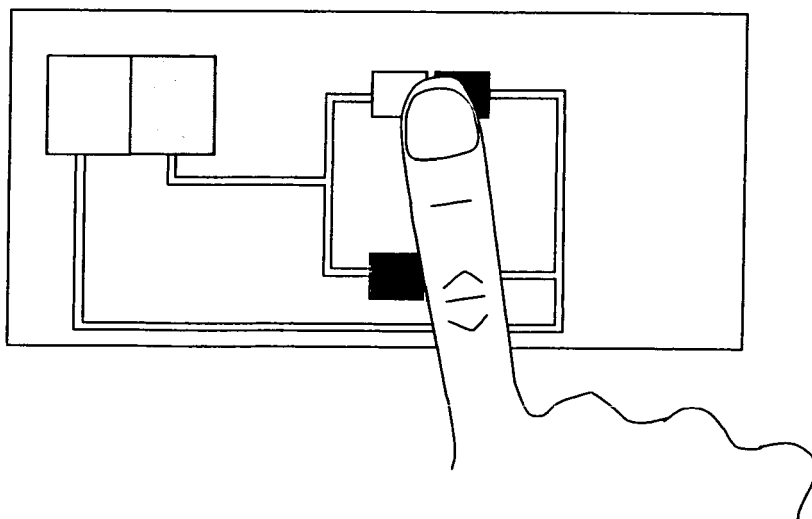


FIG. 8b





DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 03/057500 A (BUNDESDRUCKEREI GMBH; SAUTER, DIETER; BAILLEU, ANETT; POETSCHKE, KONST) 17 July 2003 (2003-07-17) * abstract; figure 1 * -----	1-7, 10, 12, 14-18, 21-27, 30-34	INV. B42D15/00
			TECHNICAL FIELDS SEARCHED (IPC)
			B42D
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 1 September 2006	Examiner Evans, A
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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